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EVALUATION OF SERMETEL W COATING FOR FASTENERS

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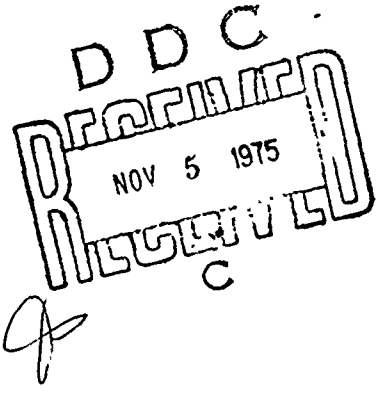

11 July 1975

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18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Fasteners
Aluminum coating (SermeTel W)
Alodine 407-47 conversion coating
Evaluation

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The evaluated coating SermeTel W with Alodine 407-47 conversion coating is intended for use on titanium fasteners, fasteners in titanium structures and alloy steel fasteners in temperature environments beyond cadmium coating capabilities. The cadmium coating is not acceptable for titanium application since titanium fasteners or titanium structures in contact with cadimum are susceptible to cracking when highly stressed even at temperatures well below 450°F. The investigation in this report included reusability

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(locking torques), torque-tension relationship, tension-tension fatigue, salt spray, coating thickness and coating continuity. The test results of samples coated with SermeTel W were compared with cadmium coated samples and were found to be suitable for alloy steel fasteners which are in contact with titanium structures or are exposed to temperatures above 450°F.

SUMMARY

Preliminary investigation of aluminum coating for use on Navy aircraft fasteners was conducted by references (a) and (b), based on these results additional evaluation of SermeTel W was conducted by this Center. The evaluated coating is intended for use on titanium fasteners, fasteners in titanium structures and on alloy steel fasteners in temperatures environments beyond cadmium coating capabilities. The cadmium coating is not acceptable for titanium applications since titanium fasteners or titanium structures in contact with cadmium are susceptible to cracking when highly stressed even at temperatures well below 450°F. The investigation in this report included reusability (locking torques), torque-tension relationship, tension-tension fatigue, 5 per cent NaCl solution salt spray, coating thickness and coating continuity. Based on the results of this investigation it is concluded that SermeTel W aluminum coating with Alodine 407-47 conversion coating and cetyl alcohol lubricant, is suitable for alloy steel fasteners which are in contact with titanium structures or are exposed to temperatures above 450°F.

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INTRODUCTION

Preliminary investigation of aluminum coating for use on Navy aircraft fasteners was conducted by references (a) and (b). Based on results of references (a) and (b) additional evaluation of Sermetel W was conducted by this Center under AIRTASK No. A05-530/001-2/5-000000000, Work Unit HQ901.

The evaluated coating consisted of Sermetel W with Alodine 407-47 conversion coating. The Sermetel W is a phosphate-chromate bonded coating containing about 60 percent aluminum and Alodine 407-47 conversion coating is a chromate-phosphate type coating for aluminum, applied by immersion.

This coating is intended for use on titanium fasteners, fasteners in titanium structures and on alloy steel fasteners in temperature environments beyond cadmium coating capabilities. Fasteners manufactured from titanium material are susceptible to galling. These fasteners require coating to prevent galling and to provide uniform load distribution. Titanium fasteners or titanium structures in contact with cadimum are also susceptible to cracking when highly stressed even at temperatures well below 450°F, reference (c). The aluminum coating would eliminate cadimum embrittlement on titanium and also hydrogen embrittlement on high strength alloy steel fasteners. The investigation in this report was limited to 1/4 inch bolts and nuts of 220 KSI Ftu strength level manufactured by Standard Pressed Steel Company to part numbers EWB TM9 and FN922 except for coatings.

The following coatings were applied to SPS bolts and nuts:

a. Exhibit A - Bolts - vacuum deposit cadmium per MIL-C-8837, Type II, Class 2; nuts - electro deposit cadmium per QQ-P-416, Type II, Class 3.

b. Exhibit B - Bolts and nuts - SermeTel W aluminum coating with Alodine 407-47 conversion coating and Silub lubricant.

c. Exhibit C - Bolts and nuts - SermeTel W aluminum coating with Alodine 407-47 conversion coating and cetyl alcohol lubricant.

d. Exhibit D - Bolts and nuts - without coating (bare), used in fatigue evaluation.

Fasteners coated with Exhibit A coating were used for comparison.

The investigation in this report included reusability (locking torques), torque-tension relationship, tension-tension fatigue, 5 percent NaCl solution salt spray, coating thickness and coating continuity.

TEST PROCEDURES

1. Cleaning

With exception of three samples of Exhibits B and C which were used

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in additional evaluation of the torque-tension relationship, all unbaked samples were thoroughly cleaned by dipping in tetrachloroethylene solvent prior to testing.

2. Baking

Eighteen samples of Exhibits B and C were baked at 900°F for six hours. These samples were used to determine plating performance after exposure to 900°F.

3. Reusability

The reusability was determined by installing and removing the nut from the bolt with no axial load for 15 full installation and removal cycles. A bolt and nut was considered fully installed when a length of two thread pitches extended beyond the nut, and the removal cycle was considered completed when locking device was disengaged. The standard torque limits for cadmium coated fasteners are as follows:

a. Size 1/4, unbaked, 30 in-lbs maximum and 3.5 in-lbs minimum.

b. Size 1/4, after bake, 60 in-lbs maximum and 3.5 in-lbs minimum.

4. Torque-Tension Relationship

The bolts and nuts from Exhibits A through C with 220 KSI cadmium plated washers under bolt heads and nuts bearing area were installed in 30,000 pound Skidmore-Wilhelm bolt tension tester. The nut was then turned while the bolt was held stationary. Torque readings were obtained using a 600 in-lbs Snap-on torque wrench.

5. Fatigue

Test fixtures, procedures and alignment used in determining the bolt fatigue strength were in accordance with MIL-STD-1312, Test 11. The tests were performed on the 5000 pound Krouse Direct Fatigue Testing Machine. The washers and nuts used in this evaluation were made to Figures 5 and 21 of MIL-STD-1312, Test 11. The bolts used were of Exhibits A through D. The high tension fatigue load for S-N curve was based on 52, 48, 44 and 40 percent of the bolt ultimate tension load and the low tension fatigue load was 10 percent of high tension fatigue load. Each point on S-N curve consisted of three samples.

6. Salt Spray

The test utilized a 5 percent NaCl solution and was conducted in accordance with MIL-STD-1312, Test 1. Five samples of exhibits A and C (two samples of Exhibit C were without cetyl alcohol lubricant) were exposed to three weeks of salt spray. The Exhibit C samples used in these tests were coated at later time since initial samples used for other tests did not have continuous coating coverage. The samples of Exhibit B were not exposed to salt spray since they failed to meet locking torque requirements.

7. Coating Thickness and Coverage

Coating thickness and coverage data was obtained from one sectioned and mounted fastener specimen of each coating type. Measurements were taken from screen projection at 400X magnification.

DISCUSSION OF TEST RESULTS

1. Reusability

The results of the locking torques are shown in Table I. The baked and unbaked samples of Exhibit C met locking torque requirements. The baked and unbaked samples of Exhibit B failed to meet locking torque requirements, see Table II.

2. Torque-Tension Relationship

The torque-tension relationship of the evaluated coatings exhibited marked differences, see Figures 1 through 8. The results of minimum torque values needed to obtain a preload of 75 percent of the bolt's ultimate strength for various coatings were as follows:

a. Exhibit A, 320 in-lbs or more, data obtained from Figure 1.

b. Exhibit B, 720 in-lbs or more, data extrapolated from Figure 2.

c. Exhibit B (samples were cleaned in tetrachoroethylene), 650 in-lbs or more, data extrapolated from Figure 3.

d. Exhibit B (samples were baked at 900^{o}F for six hours), 600 in-lbs or more, data extrapolated from Figure 4.

e. Exhibit C, 300 in-lbs or more, data obtained from Figure 5.

f. Exhibit C (samples were cleaned in tetrachoroethylene), 400 in-lbs or more, data obtained from Figure 6.

g. Exhibit C (samples were baked at 900^{o}F for six hours), 550 in-lbs or more, data extrapolated from Figure 7.

Figure 8 shows similarity in torque-tension relationship between Exhibits A and C.

3. Fatigue

The results of the fatigue tests indicate that at room temperature the samples of Exhibits B and C increase fatigue life appreciably over the samples of Exhibits A and D, see Figures 9 through 12. The comparison of fatigue life of Exhibit A versus C is shown in Figure 13. After bake at 900^{o}F for six hours the fatigue life for Exhibits B and C deteriorated appreciably, see Figures 14 and 15.

4. Salt Spray

After exposure for one week to salt spray test of 5 percent NaCl the samples of Exhibits A and C with exception of one sample from Exhibit C which had slight red rust spot in the thread area produced no initial signs of coating (white products) or fastener (red rust) corrosion. After exposure to salt spray test for three weeks, five samples of Exhibits A had slight red rust in the lightening hole of the head. One sample of Exhibit C had red rust spot in thread area and four samples had slight red rust spots on the top of the head. All five samples of Exhibit C had light to heavy white product corrosion covering up to 60 percent of the fastener area, see Table III for details.

5. Coating Thickness and Coverage

The coating thickness measurements of Exhibits B and C bolts are shown in Table IV. The first coating application on bolts of Exhibits B and C resulted in coating thickness that were not uniform or continuous, but varied from zero to 0.9 mils, see Figures 16 through 21. The coating applied to bolts of Exhibit C at later date had continuous coverage but thickness varied as follows:

a. Top of the head 0.5 to 1.3 mils.

b. Shank 0.2 to 0.8 mils.

c. Thread root 0.4 to 0.6 mils.

d. Thread major diameter 0.3 to 0.6 mils.

The nuts with Exhibit C coating had also continuous coating but the thickness varied as follows:

a. Top of the nut approximately 1.5 mils.

b. Sides approximately 2.0 mils.

c. Thread root 0.3 to 0.7 mils.

d. Thread minor diameter 0.3 to 0.5 mils.

C O N C L U S I O N S

1. Based on the test results, the fasteners coated uniformly with Exhibit C coating (SermeTel W with addition of Alodine 407-47 conversion coating and cetyl alcohol lubricant) will equal or exceed performance of the same fasteners plated with cadmium and supplementary chromate threatment, in the following areas: reusability, torque-tension relationship, tension-tension fatigue, three week salt spray and exposure to temperature of 900°F.

2. The fastener coated with Exhibit B coating did not meet performance of fastener coated with Exhibit A (cadimum) coating.

3. The Exhibit C coating appears to be suitable for titanium fasteners, since titanium fasteners with this coating were not evaluated no recommendation can be made at present time.

R E C O M M E N D A T I O N S

1. The coating of Exhibit C if applied uniformly is recommended for alloy steel fasteners which are in contact with titanium structures or are exposed to temperatures above 450°F.

2. The coating of Exhibit C is not recommended for use in temperatures above 900°F.

3. Conduct additional evaluation to determine if Exhibit C coating is suitable for titanium fasteners.

REFERENCES

(a) M. J. Zurko, Evaluation of Aluminum Coatings for Fasteners, Report No. NADC-MA-7018, 5 June 1970

(b) S. R. Brown, Corrosion Resistance of Fastener Coatings, Report No. NADC-MA-7150, 11 January 1972

(c) D. N. Fager and W. F. Spurr, Solid Cadimum Embrittlement: Titanium Alloys, Corrosion Journal, Vol. 26, No. 10, October 1970

ACKNOWLEDGEMENTS

Appreciation is expressed to Messrs. E. J. Jankowsky and L. A. Biggs for conducting and evaluating corrosion results.

TABLE I. LOCKING TORQUES (IN-LBS)

Locking Torques, Aluminum Coating, SermeTel W with Alodine 407-47 Conversion Coating and Lubricated with Cetyl Alcohol (Exhibit C).									
As Received Condition 1/					Room Temperature after Bake at 900°F for 6 Hours 2/				
Sample No.	1 Cycle (Max.)	7 Cycle (Max.)	15 Cycle (Max.)	15 Cycle (Min.)	Sample No.	1 Cycle (Max.)	7 Cycle (Max.)	15 Cycle (Max.)	15 Cycle (Min.)
1	20	10	8	7	5	50	48	40	34
2	21	11	10	7	6	32	25	23	20
3	18	11	9	6	7	42	40	32	25
4	21	16	14	7	8	42	25	20	18

1/ MIL-N-25027 requirements: 30 in-lbs max. and 3.5 in-lbs min.

2/ MIL-N-25027 requirements: 60 in-lbs max. and 3.5 in-lbs min.

TABLE II. LOCKING TORQUES (IN-LBS)

Locking Torques, Aluminum Coating, SermeTel W with Alodine 407-47 Conversion Coating and Silub Lubricant (Exhibit B).									
As Received Condition 1/					Room Temperature after Bake at 900°F for 6 Hours 2/				
Sample No.	1 Cycle (Max.)	7 Cycle (Max.)	15 Cycle (Max.)	15 Cycle (Min.)	Sample No.	1 Cycle (Max.)	7 Cycle (Max.)	15 Cycle (Max.)	15 Cycle (Min.)
9	64 3/	34 3/	30	16	13	75 3/	45	35	20
10	76 3/	32 3/	34 3/	15	14	65 3/	50	35	25
11	58 3/	48 3/	36 3/	22	15	75 3/	40	40	30
12	75 3/	70 3/	54 3/	32 3/	16	65 3/	48	45	30

1/ MIL-N-25027 requirements: 30 in-lbs max. and 3.5 in-lbs min.

2/ MIL-N-25027 requirements: 60 in-lbs max. and 3.5 in-lbs min.

3/ Samples failed to meet MIL-N-25027 requirement.

TABLE III. SALT SPRAY

Salt Spray Exposure Test Results (Salt Spray 5% NaCl)			
Number of Fasteners Tested	Fastener Coating	Time	Remarks
5	Exhibit A	1 week	No corrosion.
3	Exhibit C	1 week	No corrosion.
2	Exhibit C[1/]	1 week	On 1 sample one red rust spot on the thread near shank end.
5	Exhibit A	3 weeks	On 5 samples slight red rust in the lighting hole of the head.
3	Exhibit C	3 weeks	On 1 sample four slight red rust spots on the top of the head. All samples had light to heavy white corrosion products covering 60 percent of the area.
2	Exhibit C[1/]	3 weeks	On 1 sample one red rust spot on the thread near shank end. Two samples had light white corrosion products covering 20 percent of the area.

1/ Without cetyl alcohol lubricant.

TABLE IV. COATING THICKNESS AND COVERAGE

Exhibit	Head (Top) Mils	Shank Mils	Thread Root Mils	Thread Major Diameter Mils	Remarks
B	0 to 0.9	0 to 0.4	0 to 0.7	0.2 to 0.5	Coating coverage not continuous, see Figures 17 through 19
C first coating	0.3 to 0.5	0 to 0.5	0 to 1.0	0 to 0.3	Coating coverage not continuous, see Figures 14 through 16
C later coating	0.5 to 1.3	0.2 to 0.8	0.4 to 0.6	0.3 to 0.6	Continuous coverage. In some areas thickness too thick on the top of the head and to lesser extent on the shank.

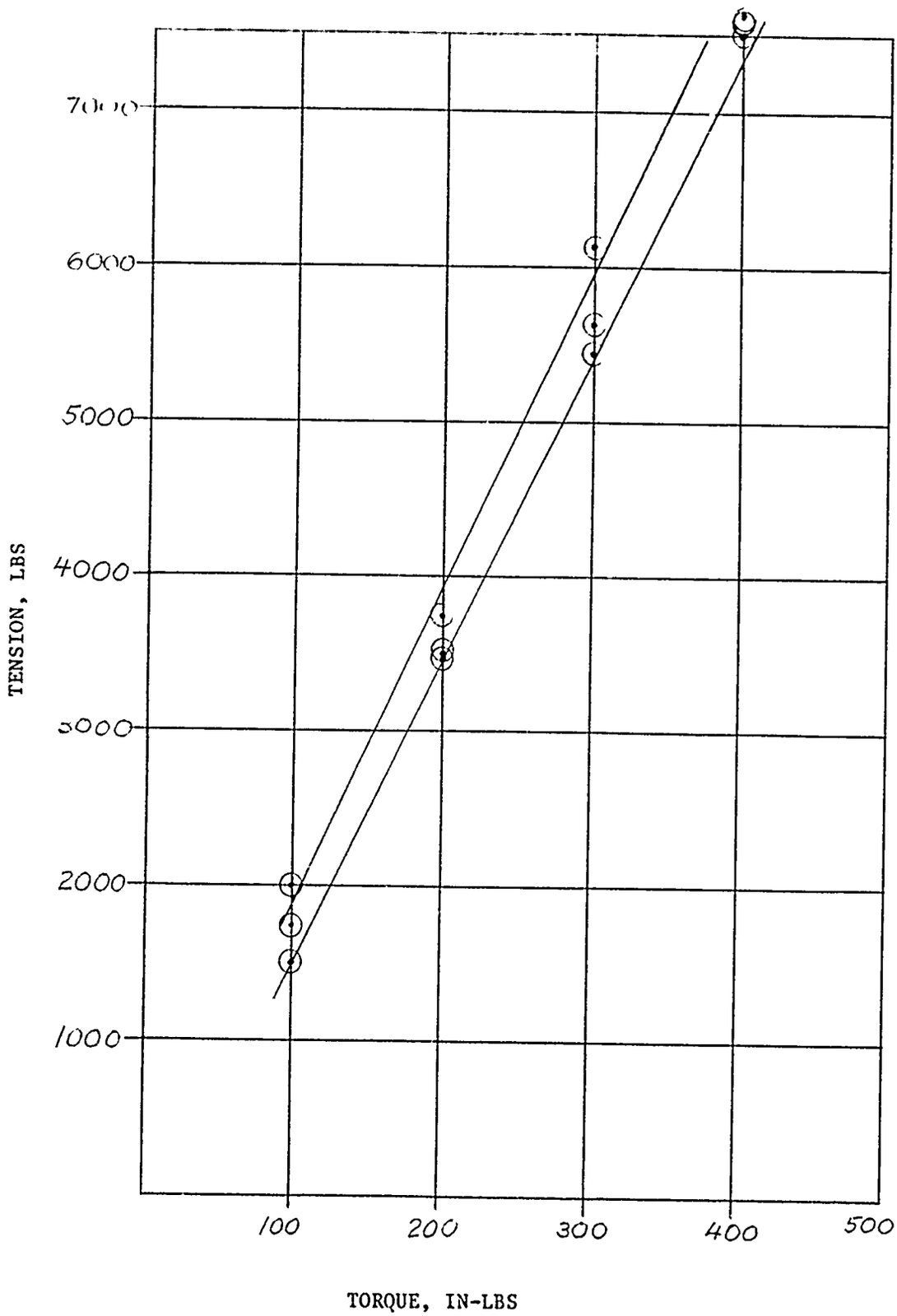

FIGURE 1. TORQUE-TENSION RELATIONSHIP FOR CADMIUM COATING

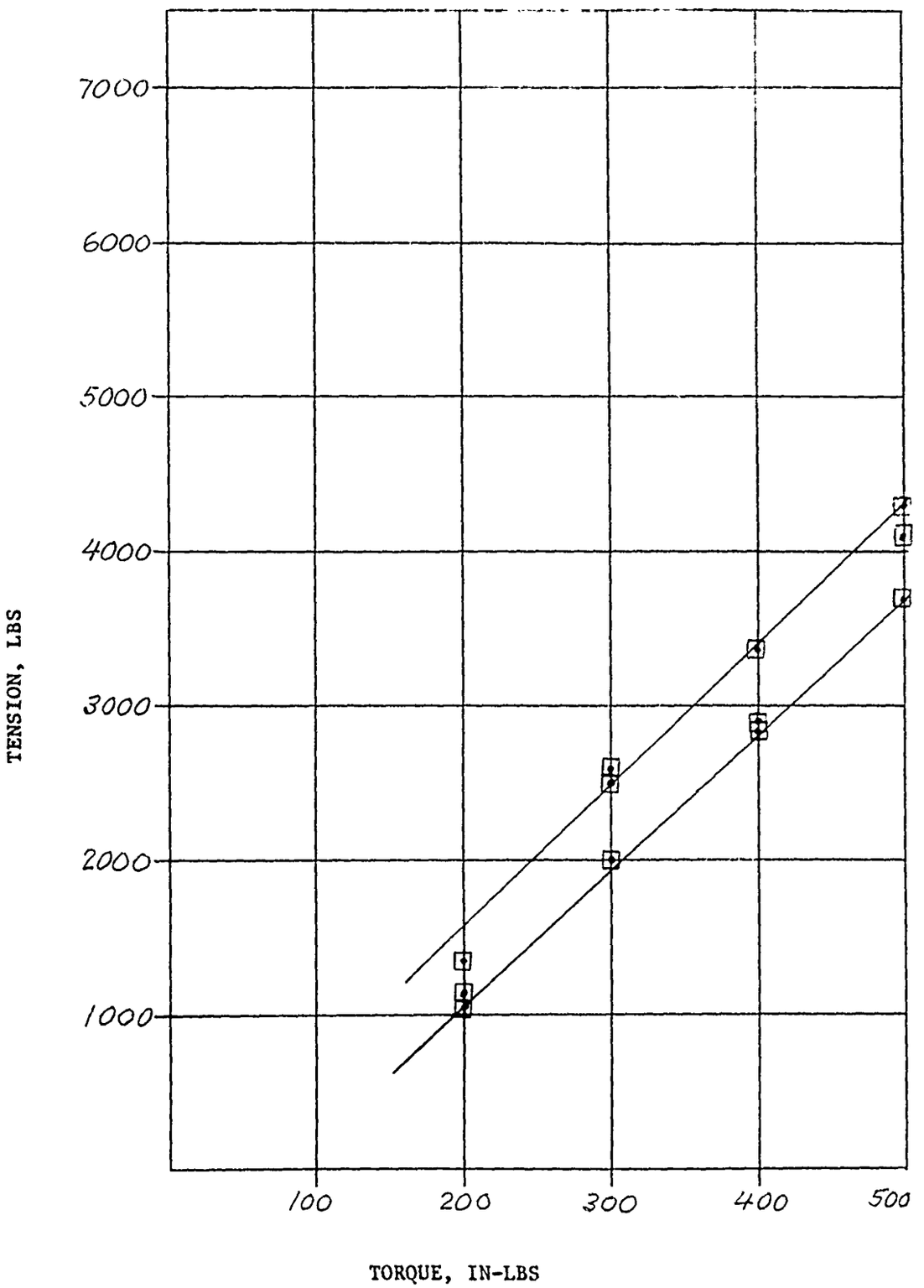

FIGURE 2. TORQUE-TENSION RELATIONSHIP FOR SERMITEL W COATING WITH ALODINE 407-47 CONVERSION COATING AND SILUB

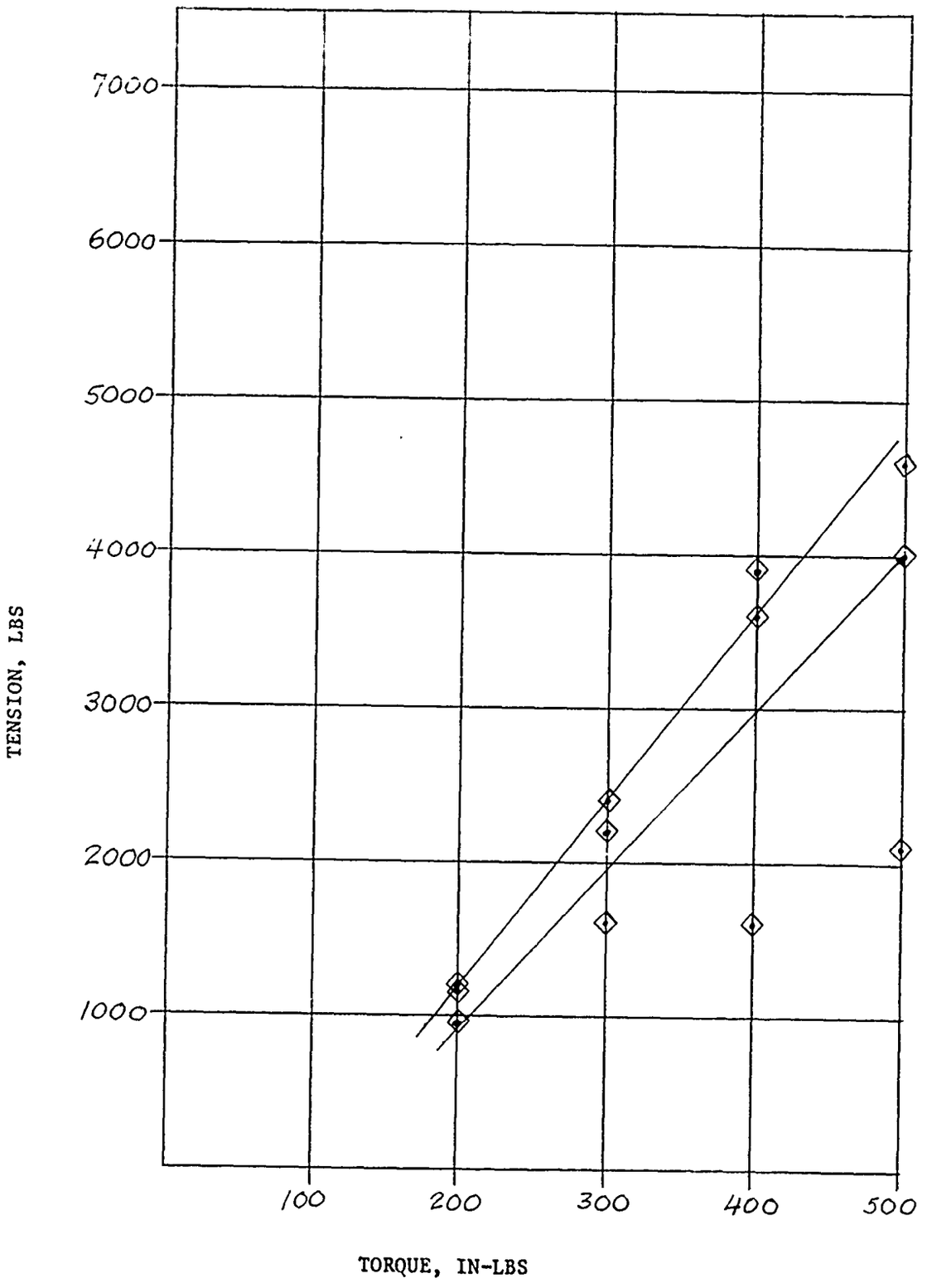

FIGURE 3. TORQUE-TENSION RELATIONSHIP FOR SERMETEL W COATING WITH ALODINE 407-47 CONVERSION COATING AND SILUB (CLEANED WITH TETRACHLOROETHYLENE BEFORE TEST).

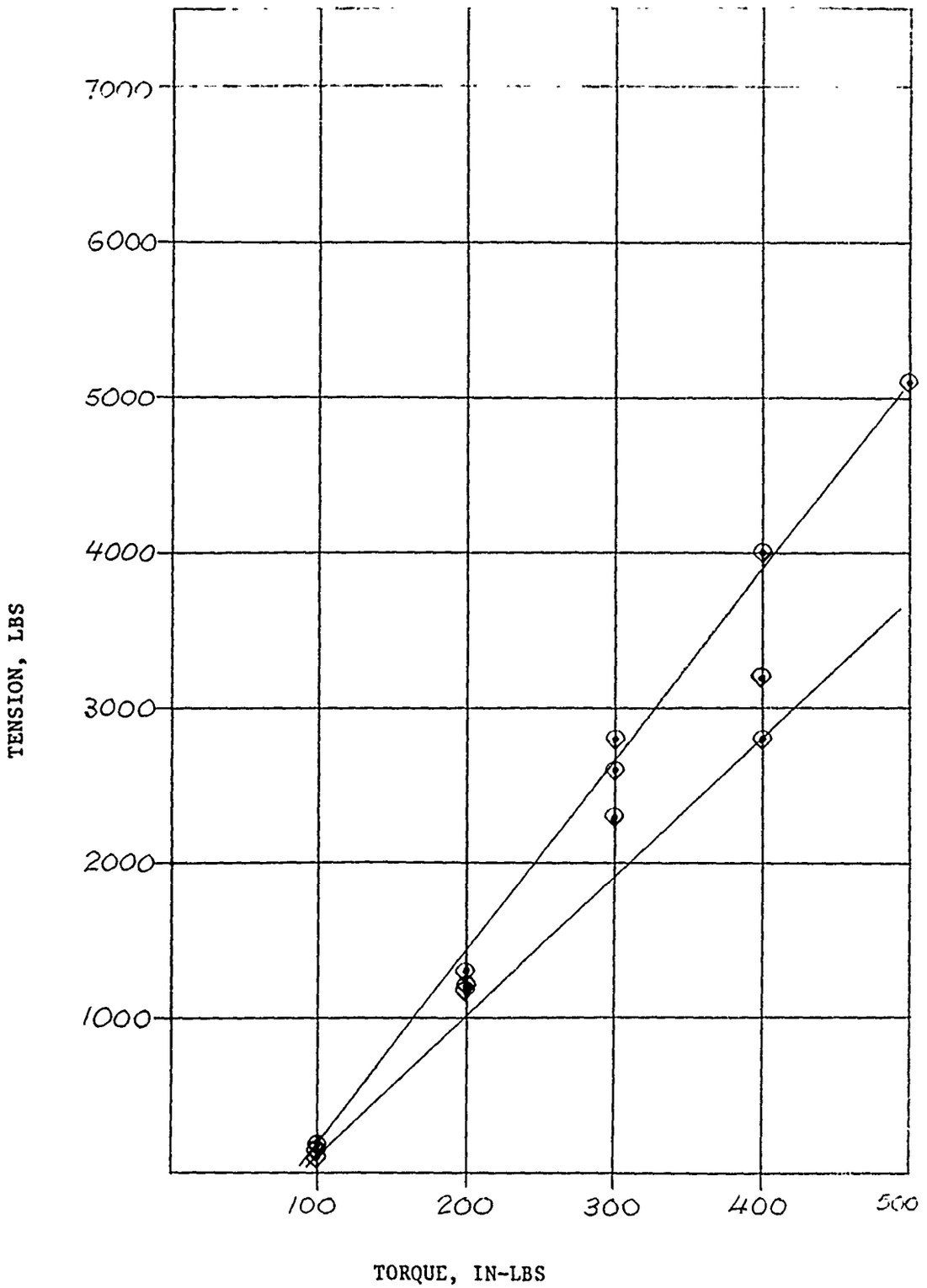

FIGURE 4. TORQUE-TENSION RELATIONSHIP FOR SERMETEL W COATING WITH ALODINE 407-47 CONVERSION COATING AND SILUB AFTER BAKE AT 900°F FOR 6 HOURS

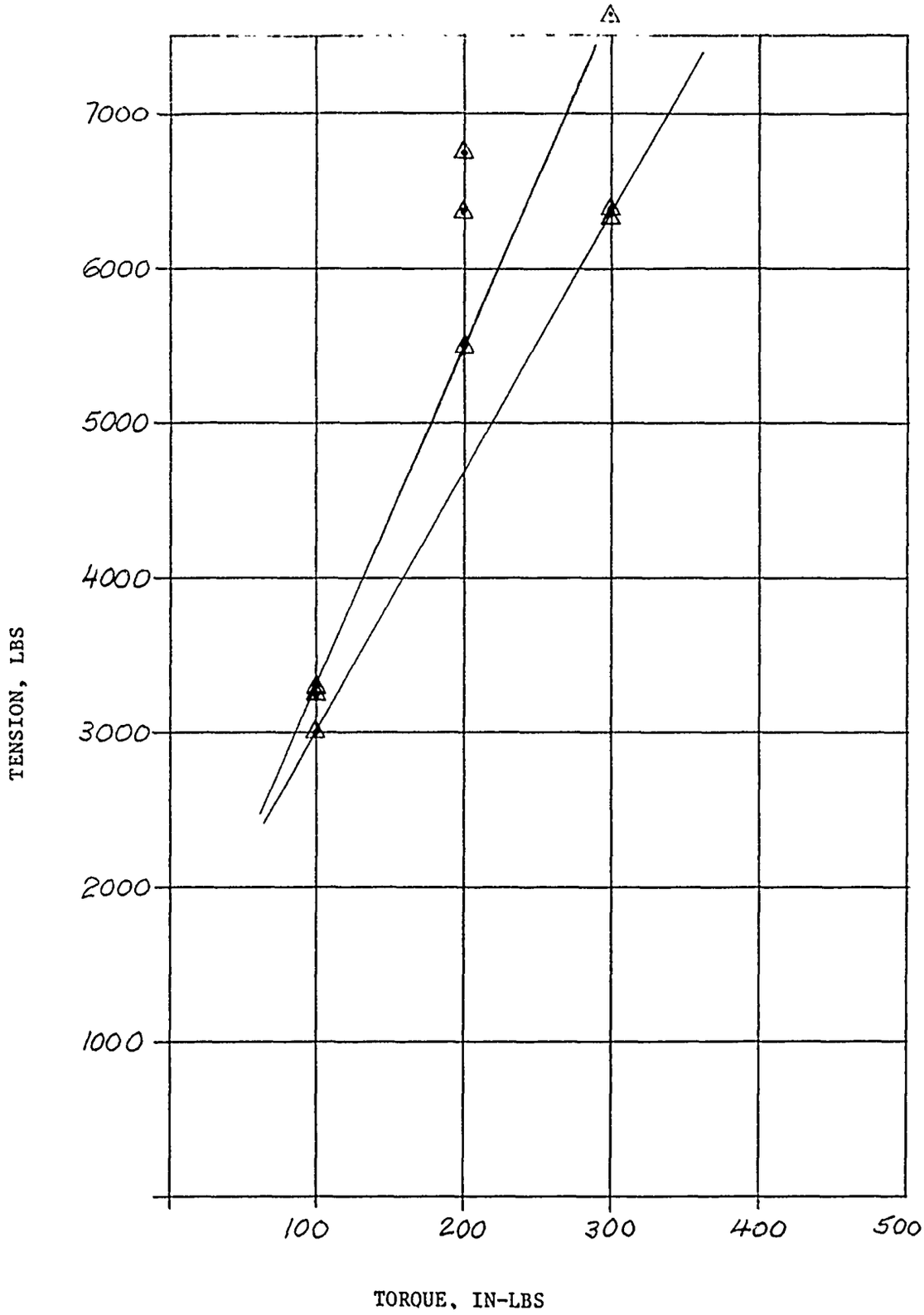

FIGURE 5. TORQUE-TENSION RELATIONSHIP FOR SERMETEL W COATING WITH ALODINE 407-47 CONVERSION COATING AND CETYL ALCOHOL

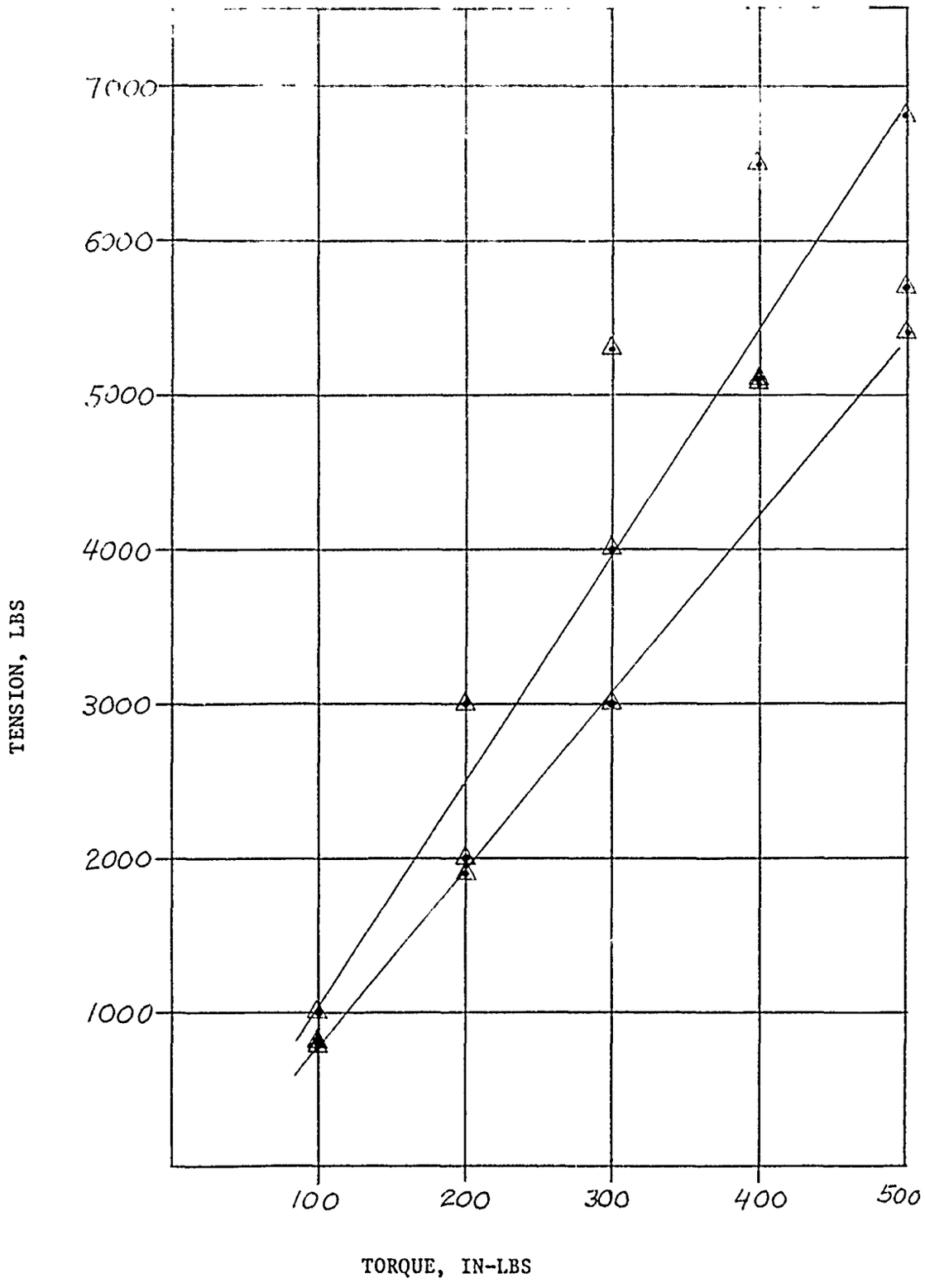

FIGURE 6. TORQUE-TENSION RELATIONSHIP FOR SERMETEL W COATING WITH ALODINE 407-47 CONVERSION COATING AND CETYL ALCOHOL (CLEANED WITH TETRACHLOROETHYLENE BEFORE TEST)

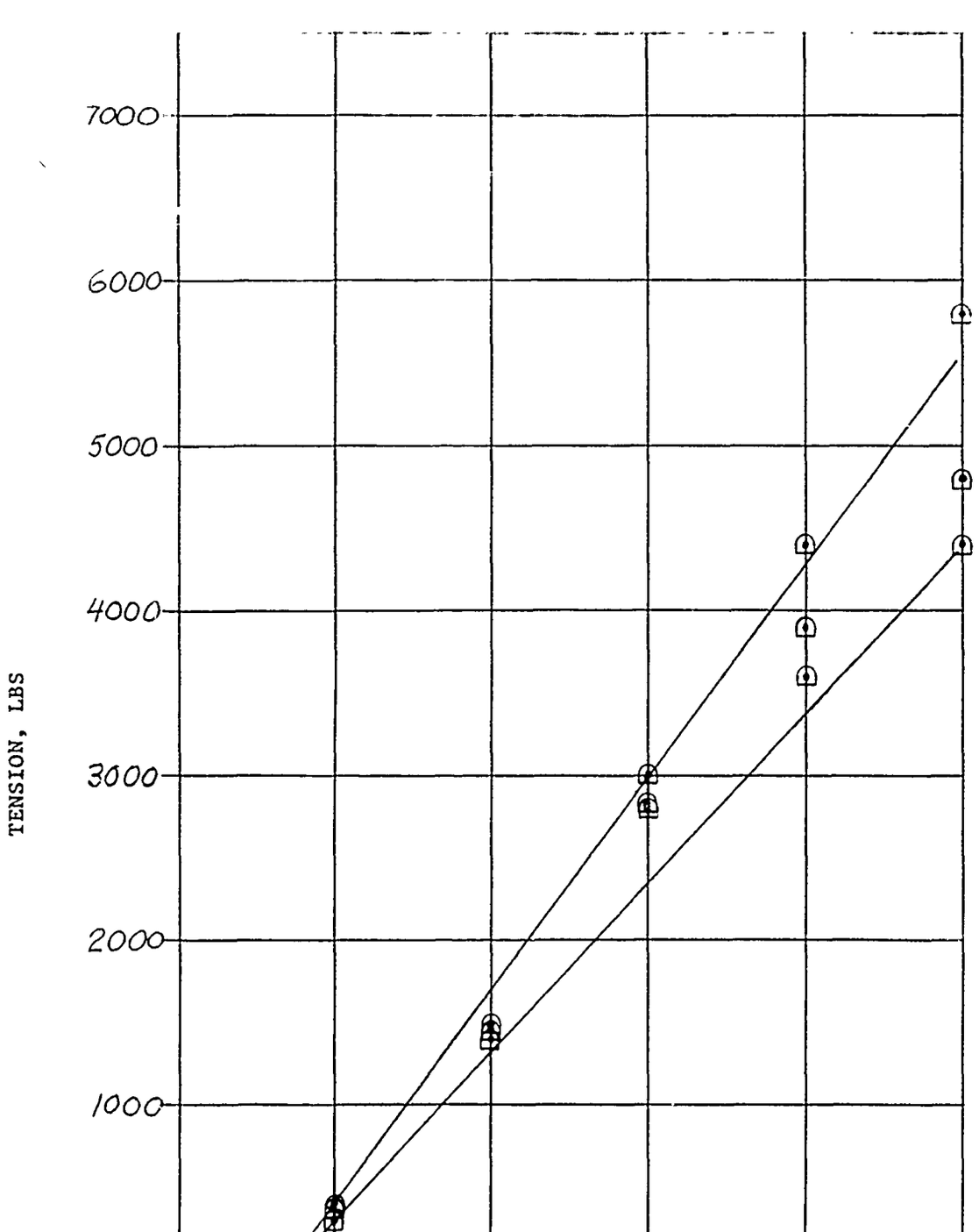

FIGURE 7. TORQUE-TENSION RELATIONSHIP FOR SERMETEL W COATING WITH ALODINE 407-47 CONVERSION COATING AND CETYL ALCOHOL AFTER BAKE AT 900°F FOR 6 HOURS

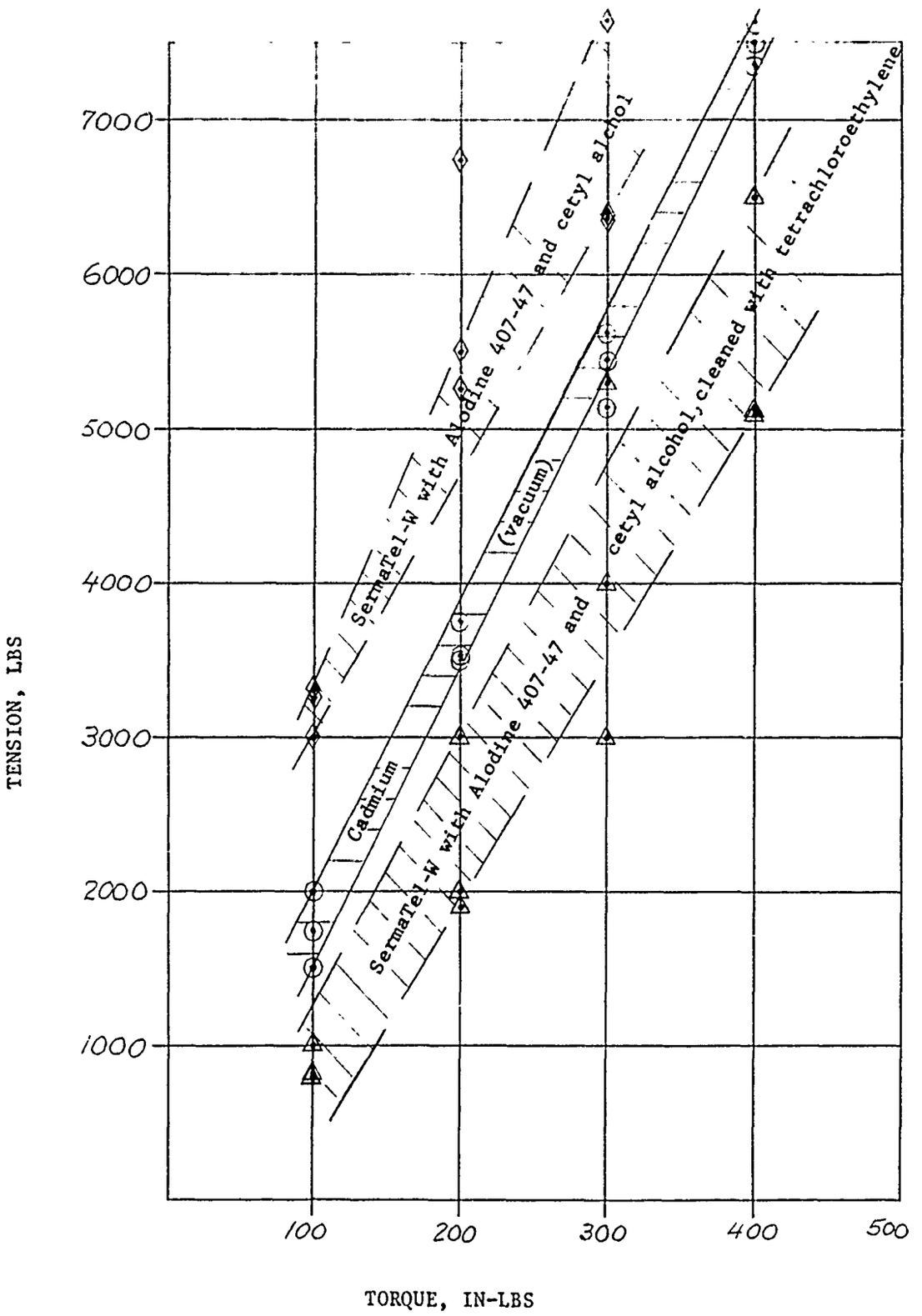

FIGURE 8. TORQUE-TENSION RELATIONSHIP, CADMIUM VERSUS SERMETEL W WITH ALODINE 407-47 CONVERSION COATING AND CETYL ALCOHOL

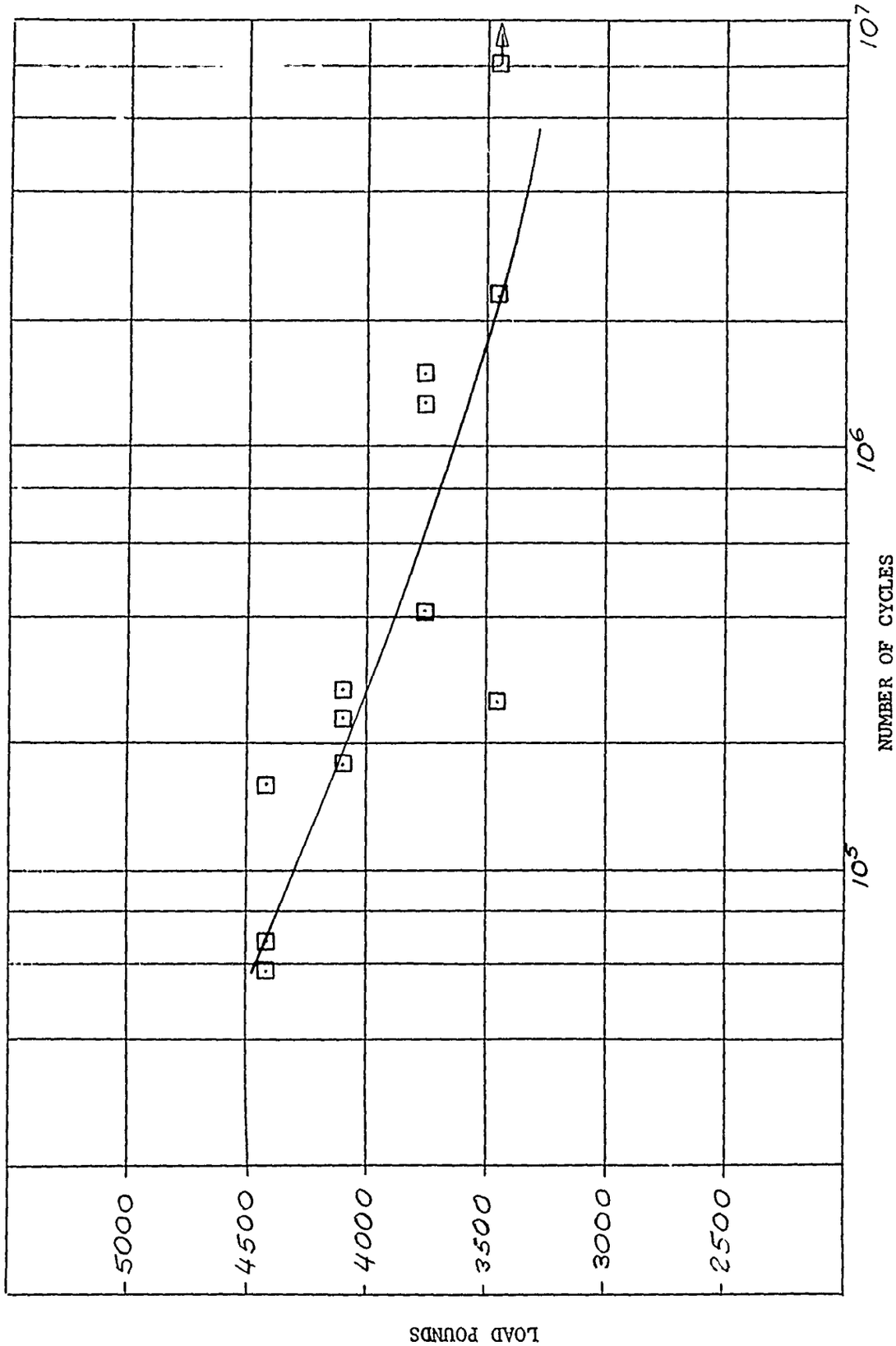

FIGURE 9. S-N CURVE FOR 1/4 INCH DIAMETER UNCOATED BOLTS

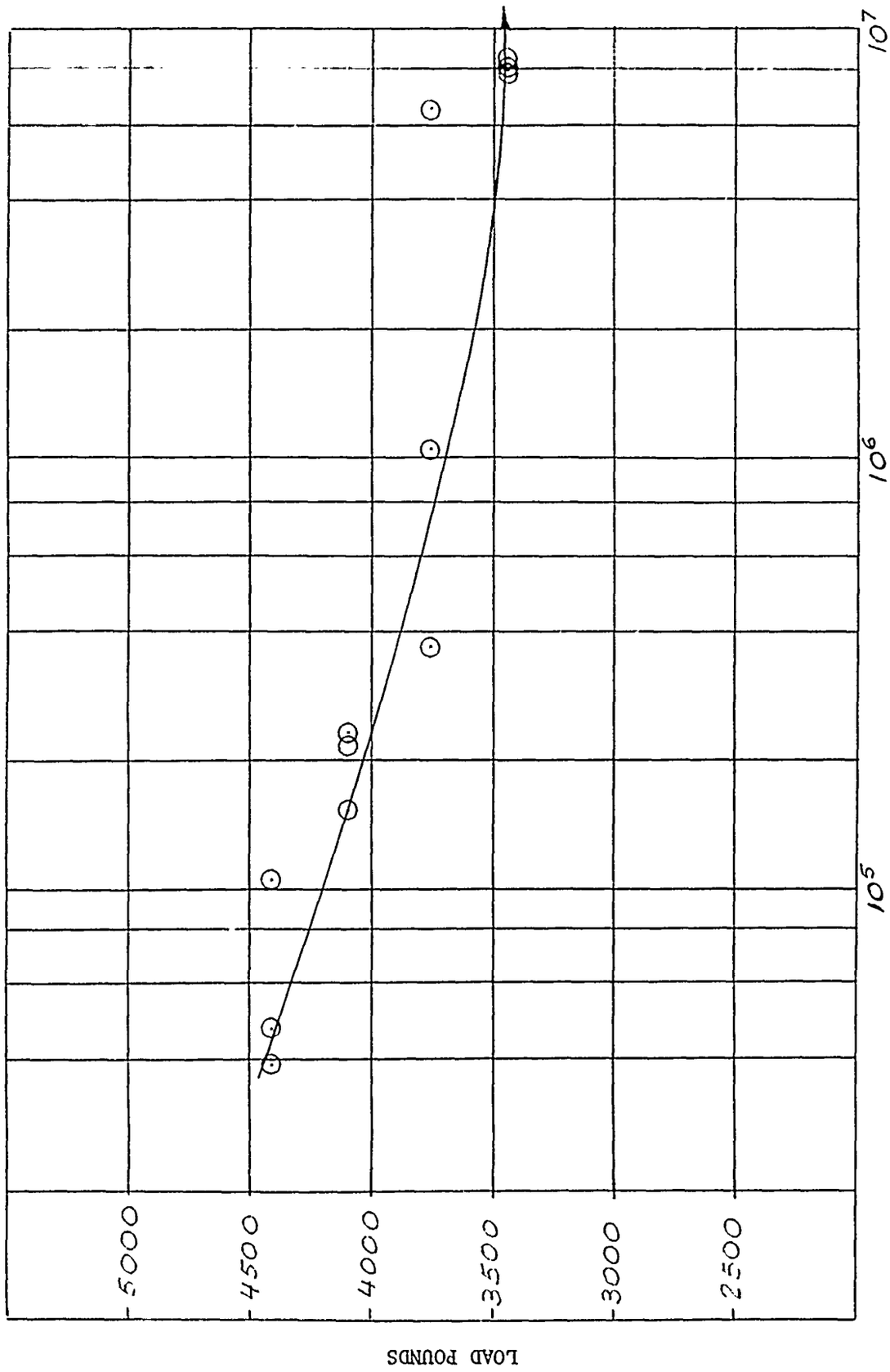

FIGURE 10. S-N CURVE FOR 1/4 INCH DIAMETER CADMIUM COATED BOLTS

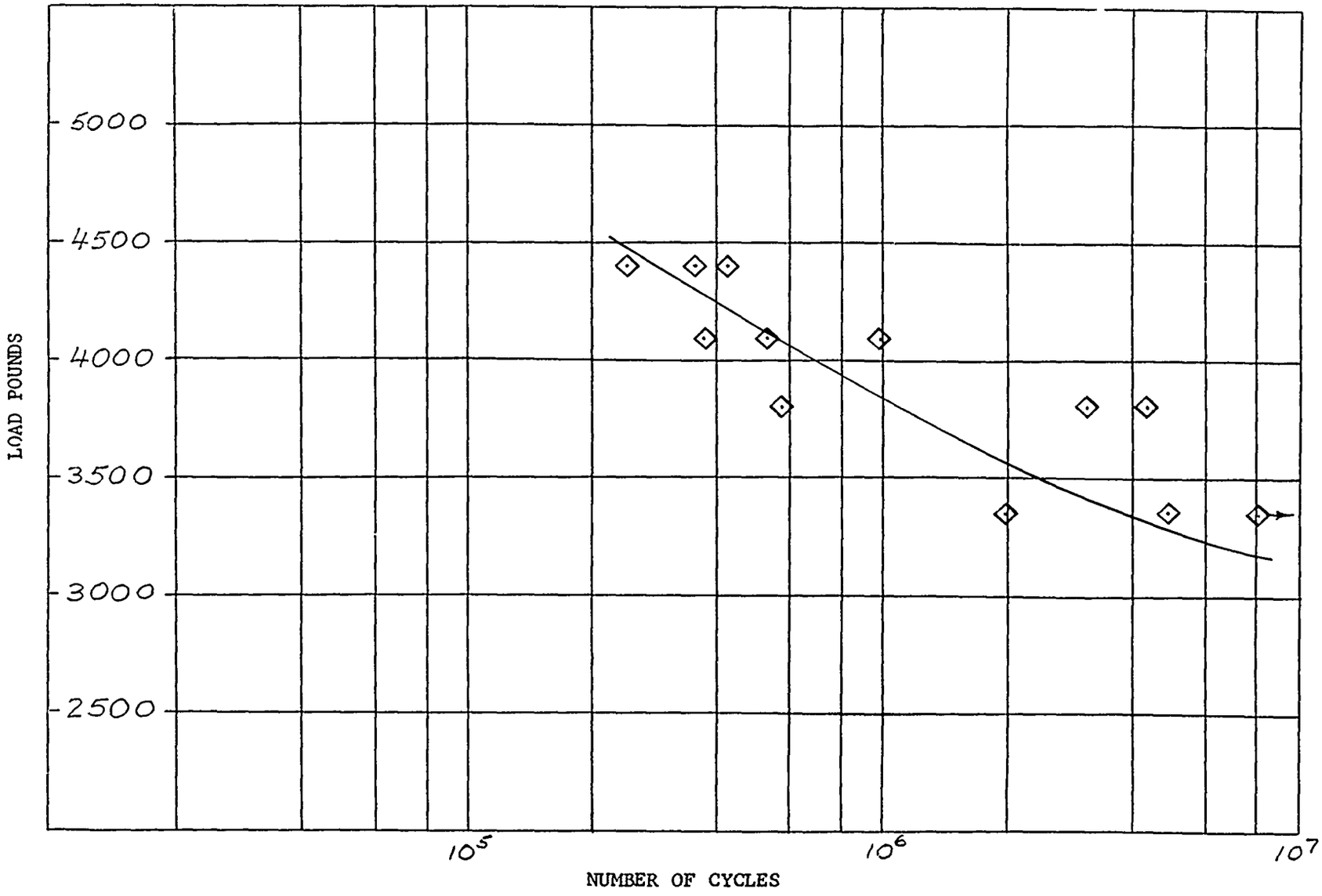

FIGURE 11. S-N CURVE FOR 1/4 INCH DIAMETER BOLT WITH SERMETEL W ALUMINUM COATING, ALODINE 407-47 CONVERSION COATING AND SILUB LUBRICANT

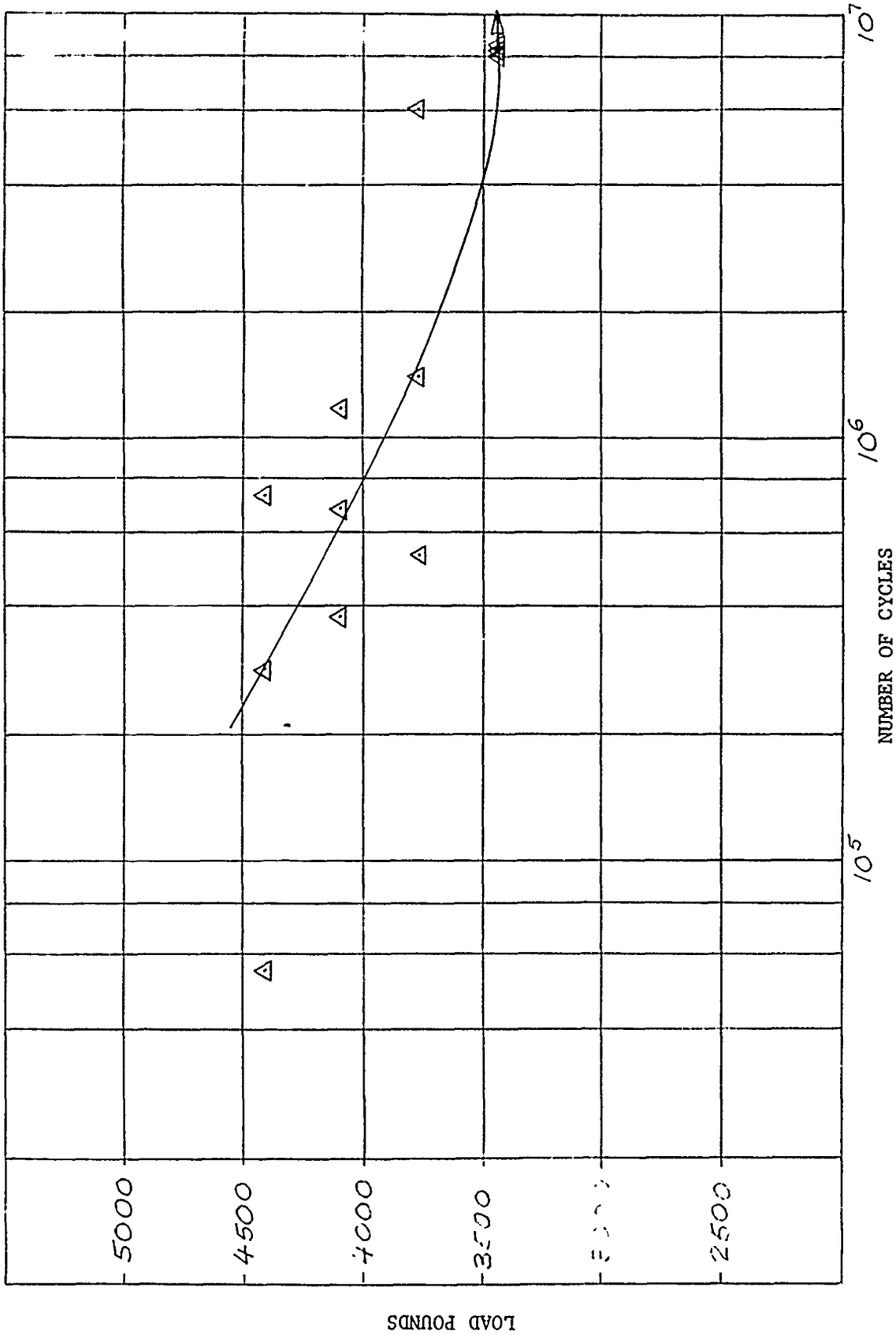

FIGURE 12. S-N CURVE FOR 1/4 INCH DIAMETER BOLT WITH SERMETEL W ALUMINUM COATING, ALODINE 407-47 CONVERSION COATING AND CETYL ALCOHOL LUBRICANT

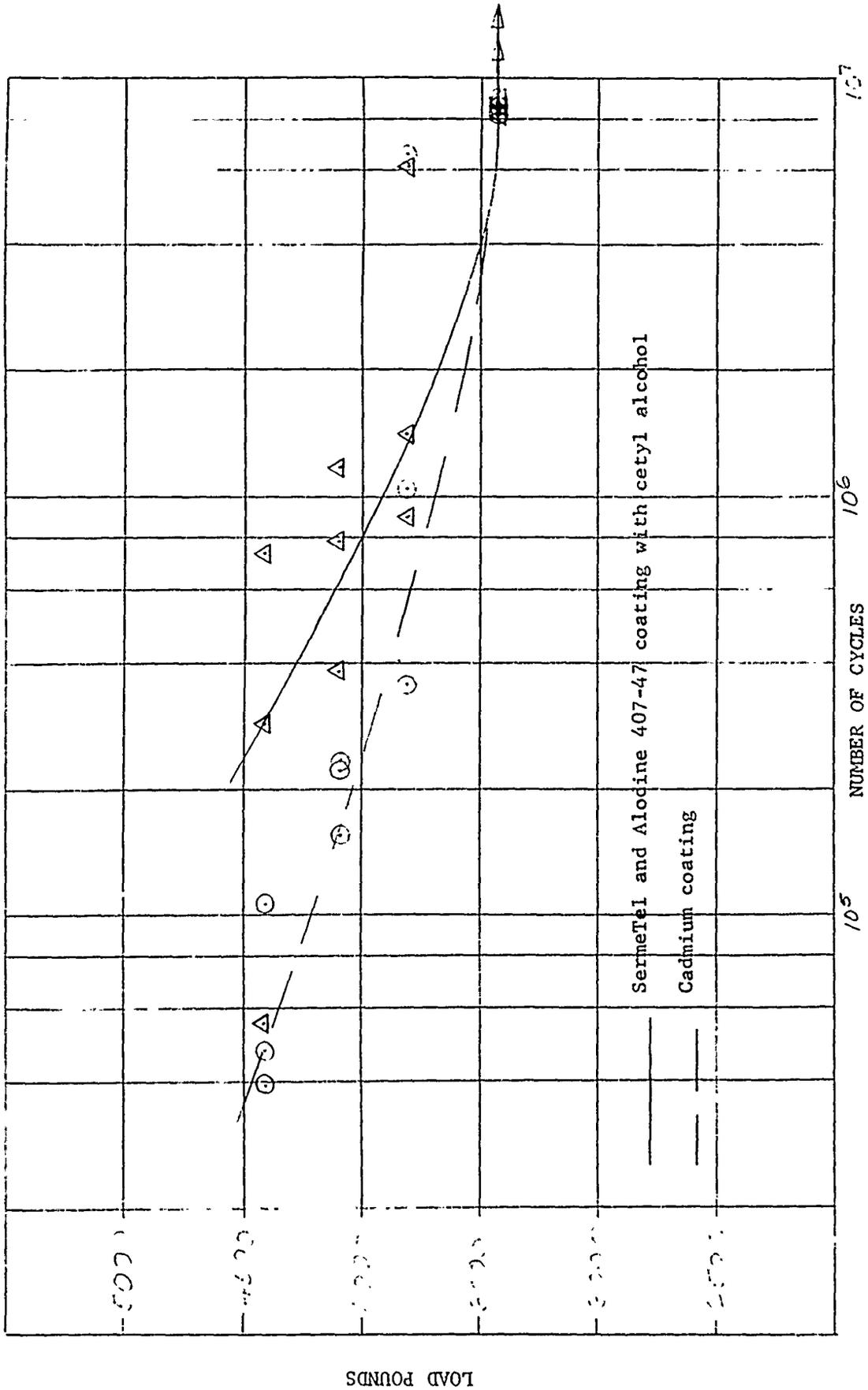

FIGURE 13. S-N CURVE RELATIONSHIP FOR ALUMINUM AND CADMIUM COATED 1/4 INCH DIAMETER BOLTS

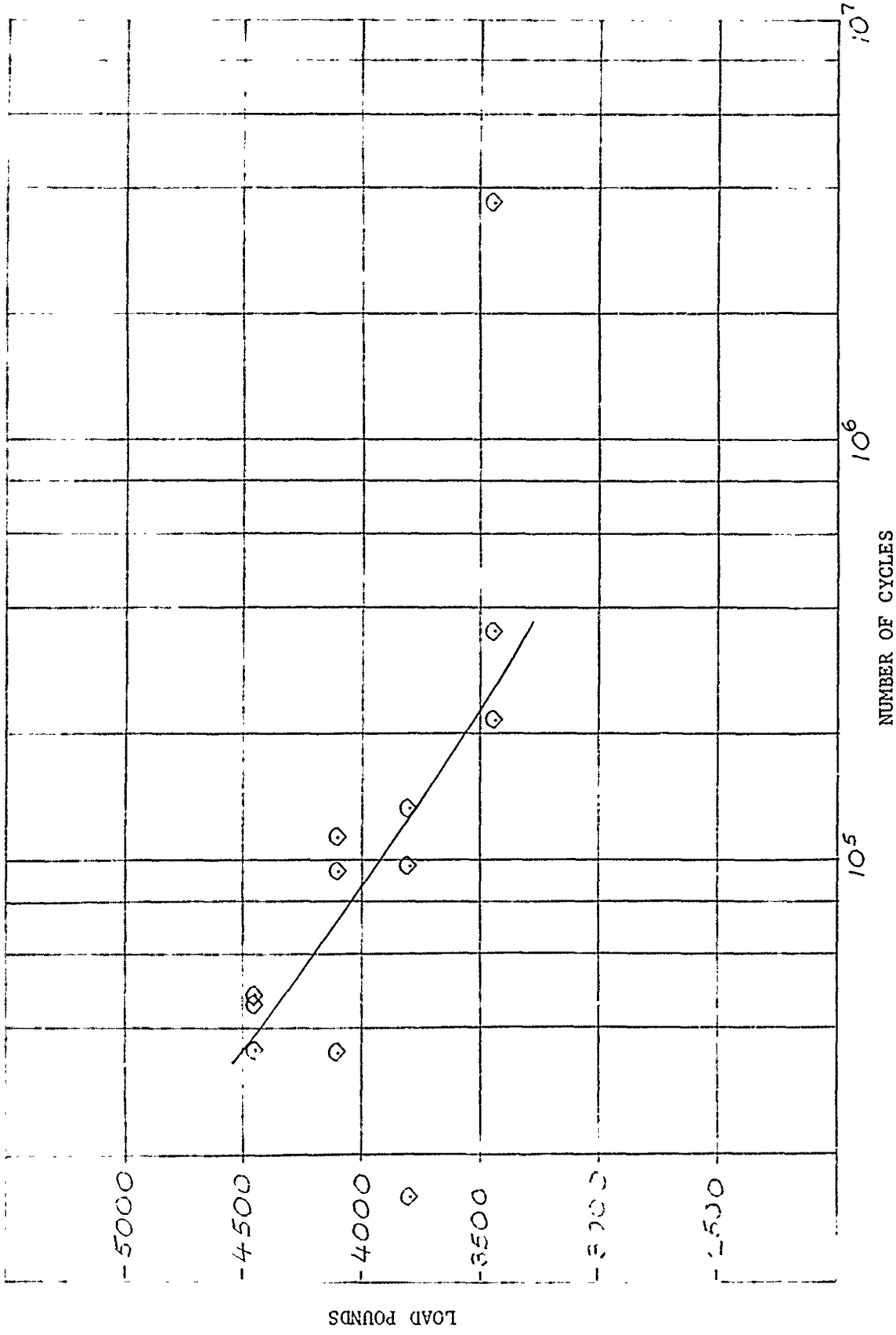

FIGURE 14. S-N CURVE FOR 1/4 INCH DIAMETER BOLT WITH SERMETEL W ALUMINUM COATING, ALODINE 407-47 CONVERSION COATING AND SILUB LUBRICANT AFTER BAKE AT 900°F FOR 6 HOURS

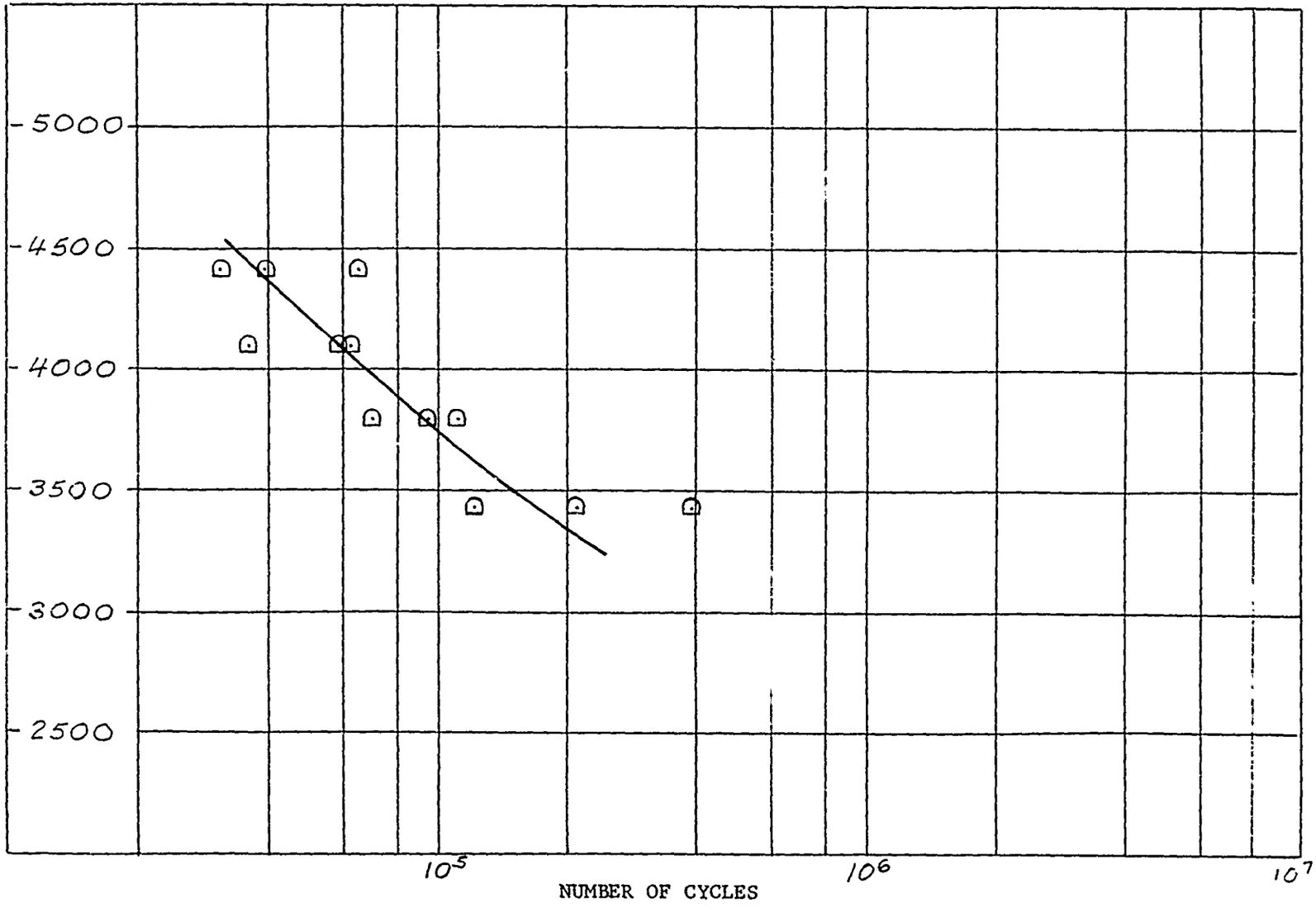

FIGURE 15. S-N CURVE FOR 1/4 INCH DIAMETER BOLT WITH SERMETEL W ALUMINUM COATING, ALODINE 407-47 CONVERSION COATING AND CETYL ALCOHOL LUBRICANT AFTER BAKE AT 900°F FOR 6 HOURS

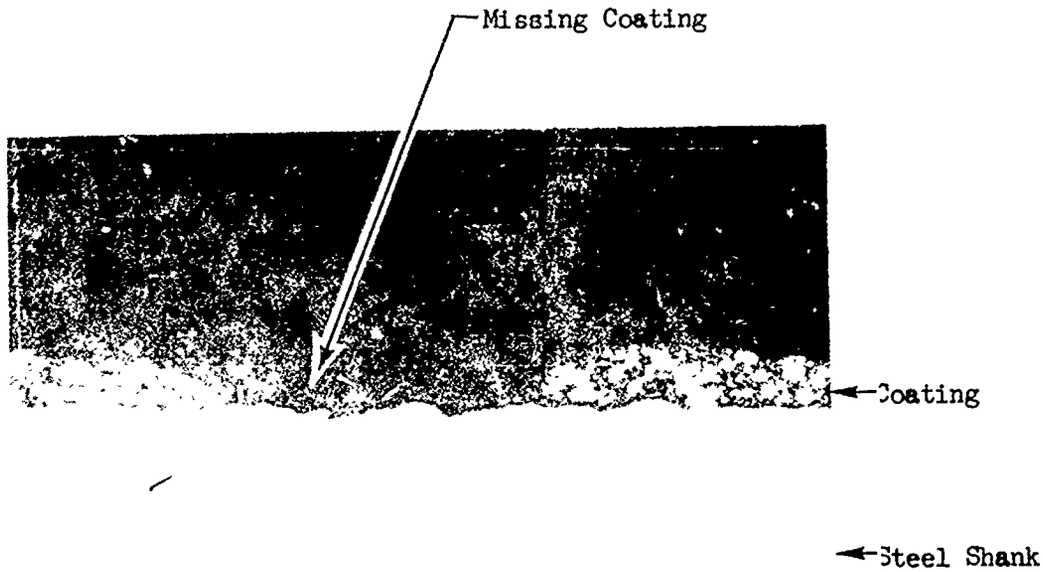

FIGURE 16. BOLT'S SHANK COATED WITH SERMETEL W, ALODINE 407-47
CONVERSION COATING AND SILUB
ORIGINAL MAGNIFICATION 400X

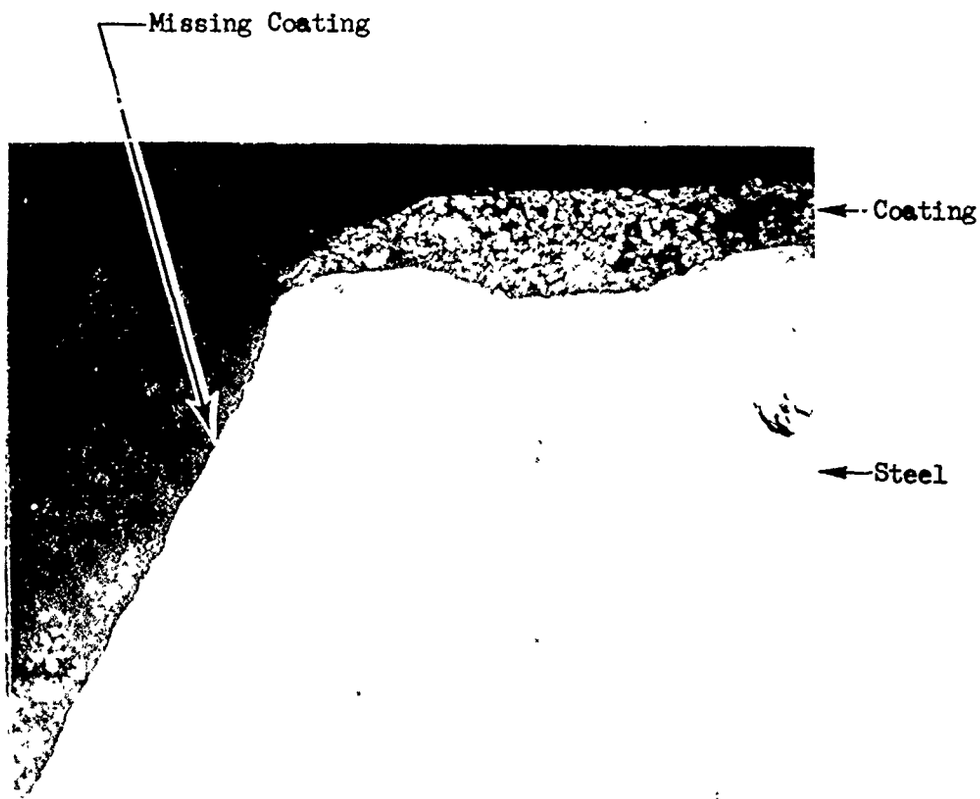

FIGURE 17. BOLT'S THREAD, MAJOR DIAMETER COATED WITH SERMETEL W, ALODINE 407-47 CONVERSION COATING AND SILUB
ORIGINAL MAGNIFICATION 400X

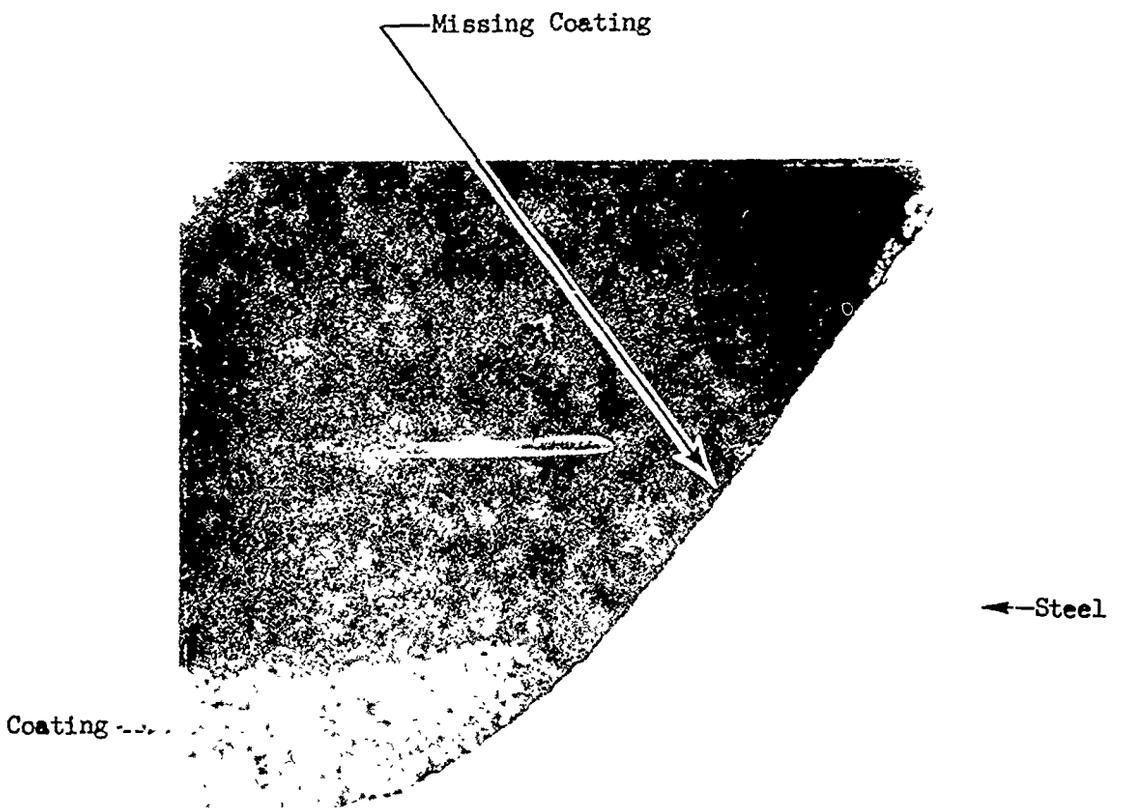

FIGURE 18. BOLT'S THREAD, MINOR DIAMETER COATED WITH SERMETEL W, ALODINE 407-47 CONVERSION COATING AND SILUB
ORIGINAL MAGNIFICATION 400X

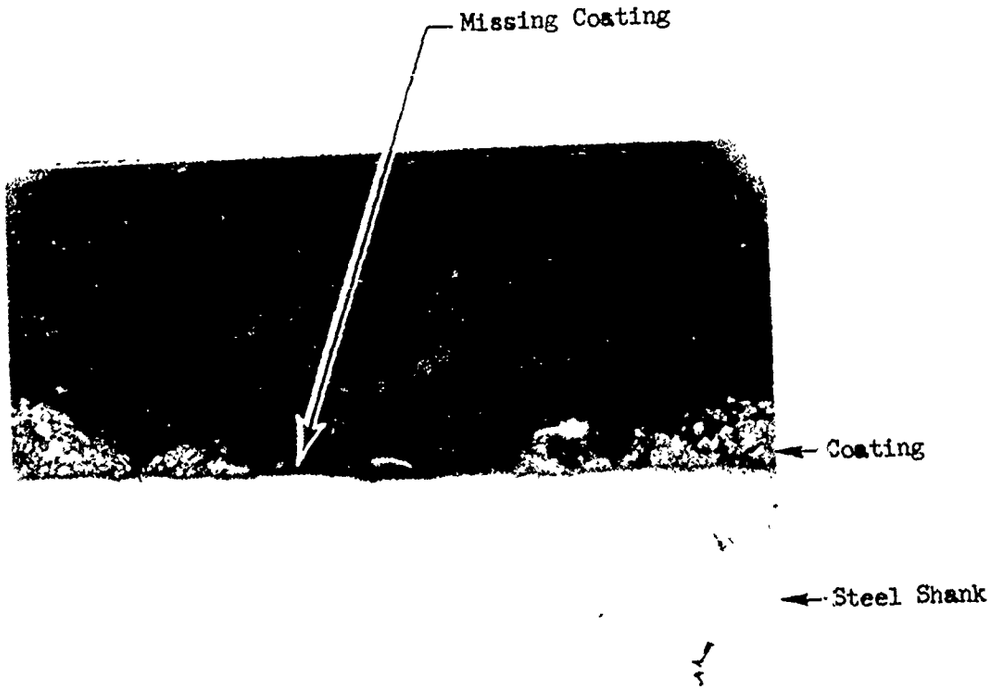

FIGURE 19. BOLT'S SHANK COATED WITH SERMETEL W, ALODINE 407-47 CONVERSION COATING AND CETYL ALCOHOL ORIGINAL MAGNIFICATION 400X

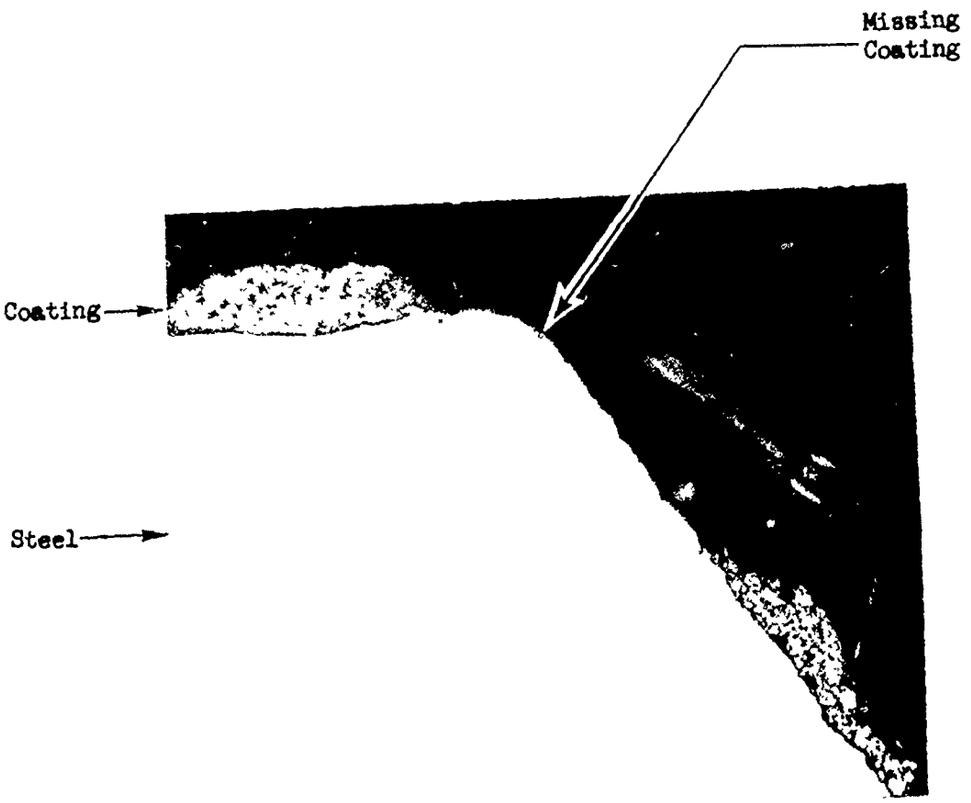

FIGURE 20. BOLT'S THREAD, MAJOR DIAMETER COATED WITH SERMETEL W, ALODINE 407-47 CONVERSION COATING AND CETYL ALCOHOL ORIGINAL MAGNIFICATION 400X

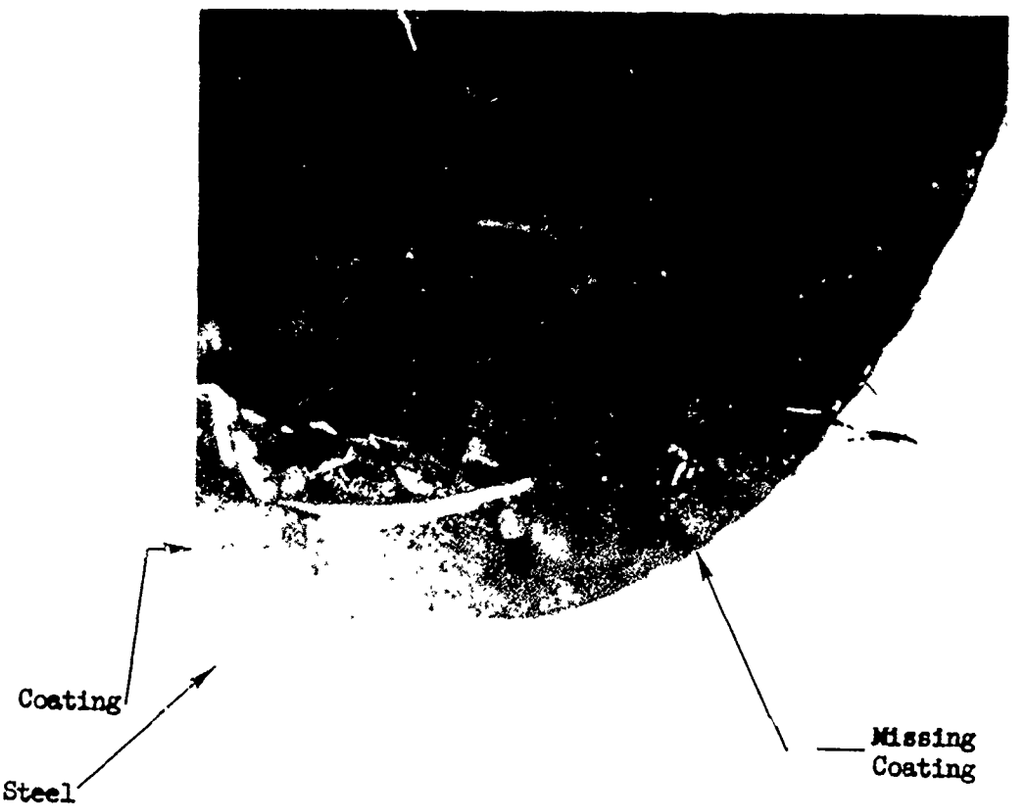

FIGURE 21. BOLT'S THREAD, MINOR DIAMETER COATED WITH SERMETEL W, ALODINE 407-47 CONVERSION COATING AND CETYL ALCOHOL ORIGINAL MAGNIFICATION 400X

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